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H1E

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(54) Piezoelectric resonator

(57) A piezoelectric resonator comprises a flat case constructed by bonding together a pair of cap members (6) having frames (105) so as to hermetically seal the interior of said case, a pair of lead terminals (7) penetrating said flat case. A sealing material is placed between the frames 105 to bond the cap members. Resonation electrodes (301) of a piezoelectric plate (8) are tightly connected to said lead terminals (7).

FIG. 2

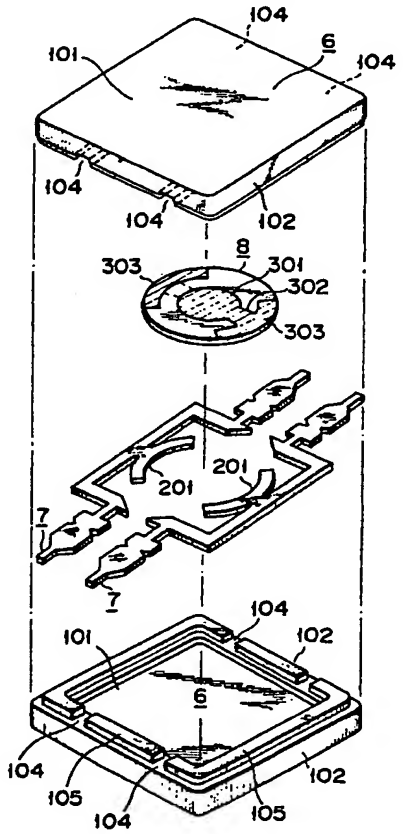

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FIG. 1

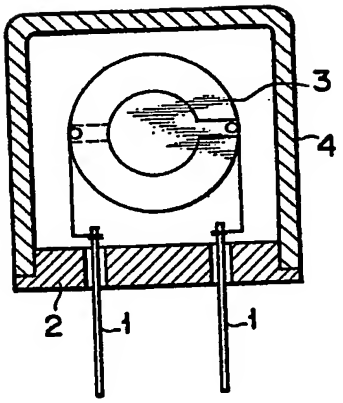


FIG. 5

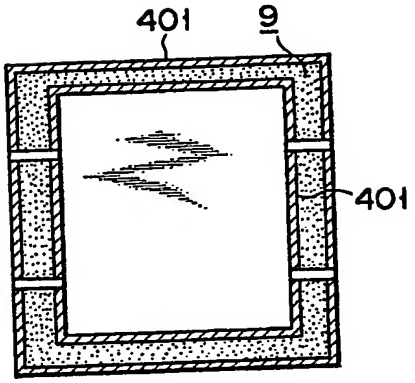


FIG. 3

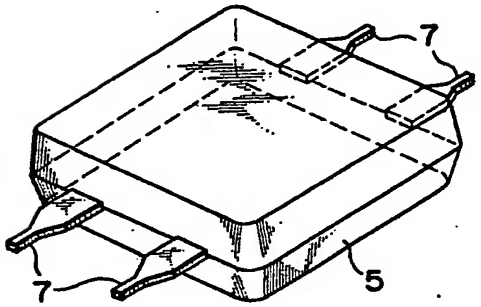


FIG. 6

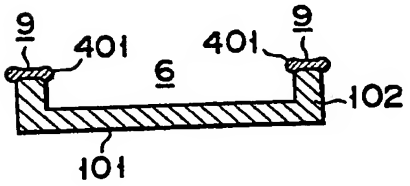


FIG. 4

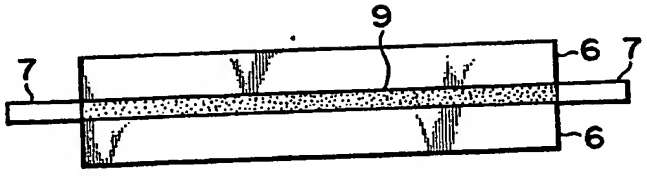


FIG. 2

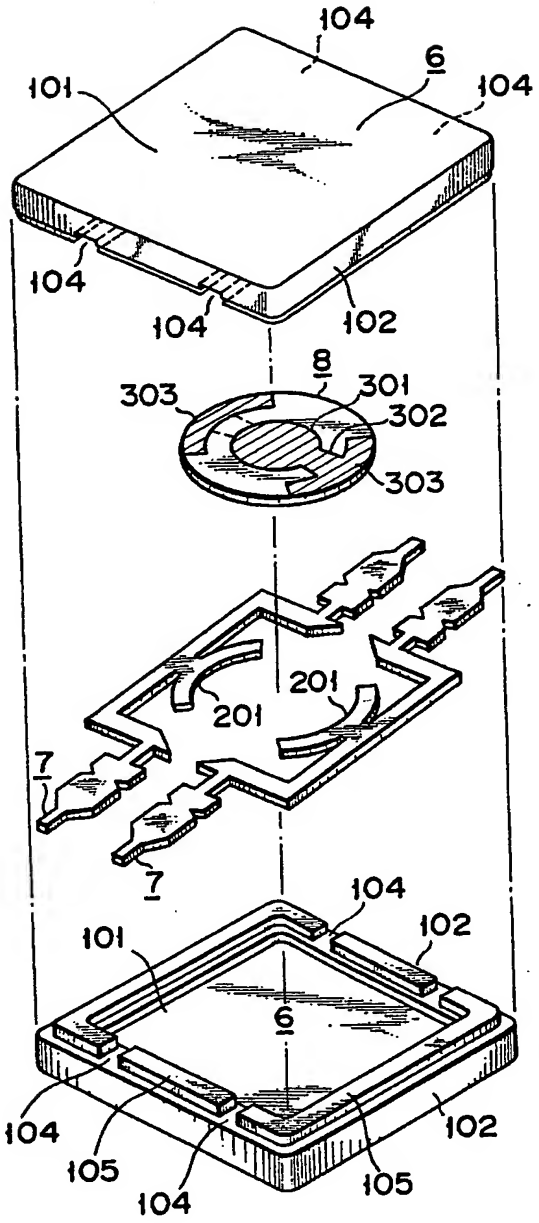

104
6
101
104
104
104
102
8
303
301
302
303
201
201
7
7
104
102
101
6
104
102
105
104
105

FIG. 7

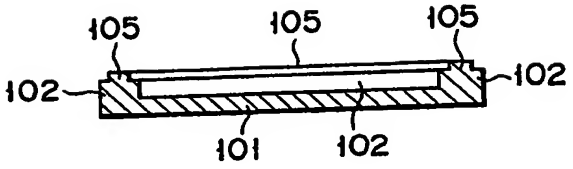


FIG. 8

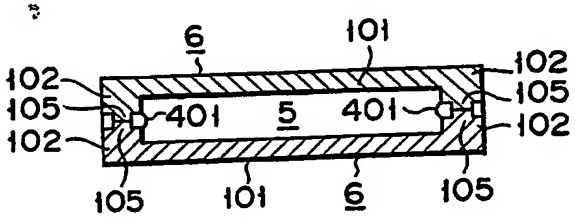


FIG. 9

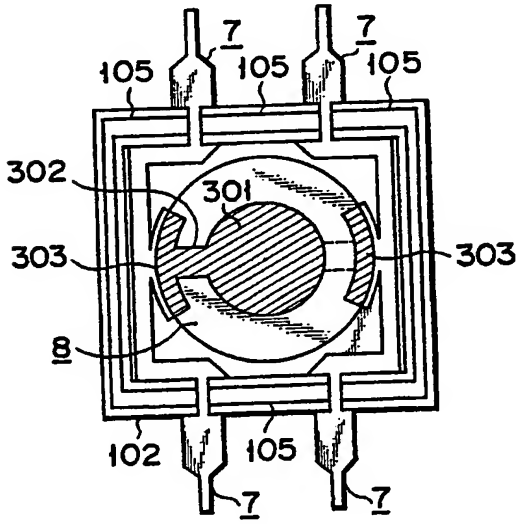


FIG. 10

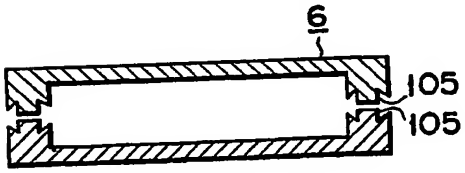


FIG. 11

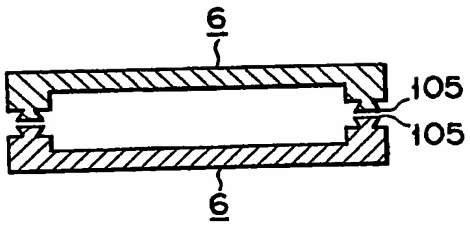


FIG. 12

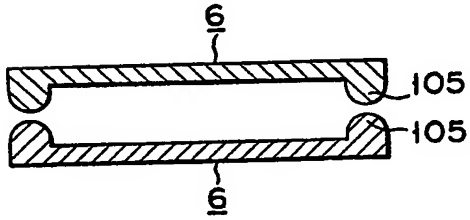
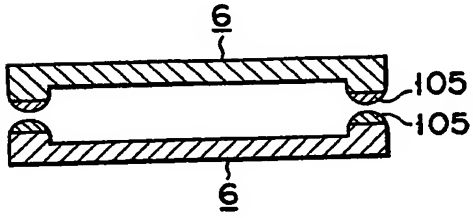


FIG. 13



SPECIFICATION

Piezoelectric resonator

This invention relates to a flat piezoelectric resonator adapted to be automatically manufactured in a highly airtight condition.

A resonator utilizing the piezoelectric function of a crystalline body, particularly a quartz resonator, generally has extremely excellent electric properties. Therefore, a large number of quartz resonators are used with, for example, telecommunication apparatuses which demanded a very stable resonation frequency.

Fig. 1 is a front section of the conventional quartz resonator which involves a pair of lead wires 1 penetrating a base 2 in an electrically insulated condition. The paired lead wires 1 are bent at the inner end in the form of a clip in order to hold the edge of the quartz plate 3. The quartz plate 3 is cut at a prescribed angle to the crystal axis in accordance with the desired resonation mode and formed in a plate shape. A metal layer is deposited as an electrode on the surface of the quartz plate by means of, for example, vacuum evaporation. The electrode extended to the edge of the quartz plate 3 is supported by the base 2 in contact with the clip portion of the lead wire 1. The edge of the opening of a cover 4 coated on the quartz plate 3 is hermetically sealed to the edge of the base 2 by resistance welding.

Therefore, the manufacture of the above-mentioned conventional quartz resonator involves the steps of fitting the quartz plate 3 to the paired lead wire 1 penetrating the base 2, carrying out the minute adjustment of the resonation frequency of the quartz plate 3, and hermetically sealing the base 2 and cover 4, thus consuming a great deal of time and work. The above-mentioned steps demand the high precision assembly of minute components, presenting extreme difficulties in the automatic manufacture of a quartz resonator device.

Recently, a quartz resonator is widely accepted in the field of not only telecommunication apparatuses, but also civilian electronic appliances, for example, microcomputers requiring a reference signal generator. Further, the electronic appliances have to be extremely miniaturized. Therefore, semiconductor elements used in, for example, the IC or LSI devices, and circuit elements such as resistors and condensors progressively tend to be miniaturized and made into a leadless chip device. The chip-shaped manufacture of, for example, circuit elements offers the advantage of securely mounting elements at a prescribed spot on the surface of a printed circuit board by using an automatic assembling apparatus such as a parts feeder, thereby noticeably elevating the assembling efficiency.

However, the conventional quartz resonator shown in Fig. 1 is accompanied with the drawback that it is necessary to insert the lead wires 1 into a partial hole drilled in a printed circuit board and securely set the wires 1 in place by means of, for example, soldering, presenting difficulties in applying an automatic assembling device such as the parts feeder and resulting in a decline in the efficiency of assembling the quartz resonator. The conventional quartz resonator has the further disadvantage that the interior of the quartz resonator is hermetically sealed by tightly pressing the cover 4 to the base 2, for example, by applying a metal part, thus increasing the cost of raw materials. Moreover, the conventional quartz resonator hermetically sealed in the cover 4 has a greater thickness than, for example, a circuit element formed into a chip, making it impossible to reduce the thickness of an actually used circuit board. Therefore, said quartz resonator has been found unadaptable to apparatuses which require a compact construction.

In view of the above-mentioned circumstances, the present inventors previously filed a patent application in the United States of America (Serial No. 632,408) for a piezoelectric resonator made into a chip shape.

The present inventors have proposed a new invention with respect to piezoelectric resonation. The invention is intended to provide a novel piezoelectric resonator which can be hermetically sealed in a flat case in a form adapted to be made into a chip shape, which can be automatically manufactured, which allows for easy automatic fitting to the surface of a printed circuit board, and which can be hermetically sealed with great ease.

This invention further provides a piezoelectric resonator comprising:

an integrally fabricated sealing case whose edge-framed paired caps are set opposite to each other;

a pair of lead terminals penetrating the side walls of said case;

a piezoelectric body whose driving electrodes are connected to the paired lead terminals; and

notches formed along the inner and outer peripheries of the upper portion of the respective caps.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a front section of the conventional quartz resonator;

Fig. 2 is an oblique assembled view of the quartz resonator of this invention;

Fig. 3 is an oblique external view of the flat quartz resonator of the invention;

Fig. 4 is an enlarged side view of the sealing member of the quartz resonator of the invention;

Fig. 5 is a plan view of a different quartz resonator, not that of this invention, which is provided with an excess amount of sealing material;

Fig. 6 is a front section of said different quartz resonator of Fig. 5;

Fig. 7 is a side section of the cap used with the quartz resonator of the invention;

Fig. 8 is a side section showing the bonded state of the paired caps used with the quartz resonator of the invention;

Fig. 9 is a plan view of the quartz resonator of the invention provided with the caps shown in Fig. 7; and

Figs. 10, 11, 12 and 13 are the sectional views of the different caps used with the quartz resonator of the invention.

A description may now be made with reference to the accompanying drawings of a piezoelectric resonator embodying this invention. Fig. 2 is an oblique assembled view. Fig. 3 is an oblique view of a finished piezoelectric resonator. Referring to Fig. 3, reference numeral 5 represents a flat case which is prepared from ceramic material or glass and whose interior is hermetically sealed. The case 5 is constructed by fitting together a pair of flat caps 6 with the same shape whose periphery is provided with uniformly high frames 102 in such a manner that said frames 102 are tightly pressed against each other in an airtight fashion. A pair of lead terminals 7 penetrate the case 5 along its plane section. Further, a pair of notches 104 is cut out at the spots through which the end portions of said paired lead terminals 7 extend outward.

The paired lead terminals 7 are formed by pressing, for example, a thin metal sheet. That portion of the lead terminal 7 which is held in the case 5 is shaped substantially like a shallow dish. Said backs of the dish portions are so set as to face each other. An arcuate projection 201 is formed at the center of the dish-shaped portions of the respective lead terminals 7 in such a manner that said arcuate projections 201 jointly constitute parts of a circle in order to securely clamp a disc-shaped quartz plate 8.

The above-mentioned disc-shaped quartz plate 8 is machined by an AT cut-thickness-shear-mode quartz resonator. A resonation electrode 301 is provided at the center of both front and back planes of said disc-shaped quartz plate 8. Lead electrodes 302 are drawn from the resonation electrodes 301 so as to extend in the opposite directions and contact a pair of mutually facing connection electrodes 303 fitted to the periphery of the disc-shaped quartz plate 8. Said connection electrode 303 is formed on both sides of the disc-shaped quartz plate 8 in such a manner that it defines an angle of $\pm 35°$ with a Z′ axis of said quartz plate 8. The connection electrode 303 of the discshaped quartz plate 8 is so fixed in place by conductive adhesive as to face arcuate projection 201 of the lead terminal 7, thereby effecting electric conduction and mechanical support between said connection electrode 303 and arcuate projection 201.

With the above-mentioned quartz resonator, precautions should be taken against the breaking the case 5 and the loss of airtightness. When, therefore, the case 5 is constructed by bonding the surfaces of the mutually facing frames 102 of the paired caps 6 by a sealing material 9, as shown in Fig. 4, it is necessary to reduce the thickness of said sealing material 9 by applying a sufficiently great pressure, in order to ensure the hermetical sealing of the interior of the case 5 by raising the bonded strength of the frame sections 102. If, in this case, too much sealing material 9 is applied, the difficulties arise as shown in the plan view of the quartz resonator of Fig. 5 and its front sectional view of Fig. 6, i.e., the sealing material 9 leaks from the surface of the frame sections 102 to the outside and inside of the case 5. Though elevating the bonded strength of the paired caps 6, the excess application 401 of the sealing material 9 is accompanied with the drawbacks that the properties of the disc-shaped quartz plate 8 are deteriorated by the excess sealing material 401 on the outside of the case 5 impairs the attractiveness of the quartz resonator; and in the case where the quartz resonator is demanded to have rigidly precise dimensions, the deposition of the excess sealing material 401 leads to dimensional errors and the production of an increased number of rejected quartz resonators. Conversely, where too little sealing material 9 is applied, the case 5 decreases in its bonded strength or in its airtightness. In bonding the paired caps 6, therefore, close care should be taken with respect to the quantity of the sealing material 9 to be applied, thus sometimes obstructing the efficiency of manufacturing a quartz resonator.

In view of the above-mentioned circumstances, the method of this invention for manufacturing a quartz resonator is characterized in that, as seen from Fig. 7 showing the cross section of one of the cap members 6, a projection 105 is formed at the center of the surface of the respective frame sections 102. As seen from Fig. 8, the provision of said projection 105 offers the advantages that when the paired cap members 6 are bonded together, the excess sealing material 401 flows into a space defined by the projections 105 formed on the surface of the frame sections 102 to fill up said space, thus the bonded strength of the case 5 is increased over the level which is defined by the total surface area of the frame sections 102. The airtightness of the interior of the case 5 is also increased. When, therefore, a considerably high pressure is applied in fabricating the case

5 by bonding together the paired cap members 6, it is possible to suppress the drawbacks that the excess sealing material 401 leaks to the outside and inside of the case 5, resulting in its dimensional errors and deterioration of the properties of the disc-shaped quartz plate 8 by the deposition of said excess sealing material 401 on its surface.

Fig. 9 is a plan view of a quartz resonator which is constructed by connecting a disc-shaped quartz plate 8 electrically and mechanically to the lead terminals 7, with one of the paired cap members 6 taken off.

It will be noted that this invention is not limited to the foregoing example. It is possible to form the projection 105 on the surface of the frame sections of the paired cap members 6 in such a manner that the central portion of the cross section of said projection 105 bears a rectangular shape and the outer and inner sides of said projection 105 consist of wedge portions have a prescribed angle. It is also possible to form said projection 105 in the dovetail shape, as seen from Fig. 11. Further, it is possible, as shown in Fig. 12, to form said projection 105 with an arcuate cross section. Further, as illustrated in Fig. 13, a separate projection 105 may be provided on the paired cap members 6 by depositing, for example, molten glass in the arcuately protruding form.

CLAIMS

1. A piezoelectric resonator comprising:

a pair of cap members, the periphery of each of said cap members being provided with a frame section and the surface of said frame section being provided with a projection;

a sealing material for bonding the whole of the frame sections of said cap members to constitute a case;

a pair of lead terminals penetrating the lateral walls of the case; and

a piezoelectric member constructed by fitting said paired lead terminals with the corresponding resonation electrodes.

2. The piezoelectric resonator according to claim 1, wherein the projections on the frame sections are integrally formed of the same material.

3. The piezoelectric resonator according to claim 1, wherein the projections on the frame sections are prepared from a different material than that of said frame sections.

4. The piezoelectric resonator according to claim 3, wherein said projections are prepared from molten glass.

5. A piezoelectric resonator, substantially as hereinbefore described with reference to the accompanying drawings.

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